

**TESTIMONY OF JEFF HAWK – DIRECTOR  
CERTIFICATION, ENVIRONMENT AND GOVERNMENT RELATIONS  
THE BOEING COMPANY**

**BEFORE THE HOUSE AVIATION SUBCOMMITTEE**

**February 15, 2006**

**Introduction**

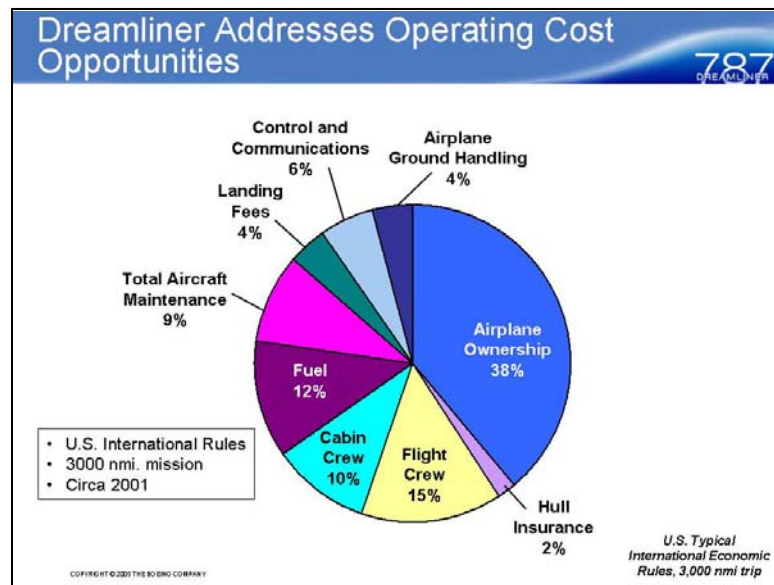
Good morning. I am Jeff Hawk, the director of Environment, Certification and Government Relations for the Boeing 787 Dreamliner program. It is my pleasure to be here today representing the thousands of Boeing workers who design, build and support the world's finest commercial jetliners. I have worked at Boeing for more than 30 years and have worked on every airplane since the 727. I have seen first hand how Boeing continually improves its products in terms of the fuel efficiency and overall environmental performance and how Boeing introduces new levels of performance with each new airplane it brings to market. Our engineers and technical experts have devoted themselves to making meaningful improvements year after year as new technologies and approaches have been developed.

I have been asked to talk today about Boeing's commitment to continuous improvement in the environmental performance of our commercial jet transports –with specific focus on fuel efficiency. I would like to begin by explaining how we came to the decision to build the 787 and explain to the committee the characteristics that make it a new airplane for a new world. I plan to also briefly explain the integration of technology that made these advancements possible. I will also highlight recent advancements in the fuel efficiencies of other Boeing aircraft and then I will conclude by pointing out how building a new and more efficient air traffic control regime will also aid in reducing fuel consumption in the future.

There are two reasons we take our commitment to improved fuel efficiency so seriously at Boeing. First, it is the right thing to do. We know that our planet does not offer inexhaustible resources to be used thoughtlessly. It is incumbent upon us to deploy the new technologies that will help our industry to use our resources most wisely. This has caused us to take a lifecycle approach to our development efforts. In this way, we look at the entire life of an airplane – from its initial design to manufacturing to its in-service operation and support to eventual retirement of the airframe - to ensure we are incorporating all that is feasible to reduce the use of precious resources, and limit the emissions created while maximizing the ability to recycle and reuse airplane materials.

Secondly, like any other business, Boeing must respond to the needs of our customers, understand the trends within our industry and face our competition with superior products. Our work with airlines here in the U.S. and around the world has made it exceedingly clear that they need more efficient aircraft and tools to operate their businesses. The current financial challenges of the U.S. industry are well known and widespread. Much of the financial difficulty in the U.S. industry is related to the cost of fuel. We developed the 787 in large part to address these concerns, and clearly, the airline marketplace is positively responding to our new product.

## The Genesis of the 787

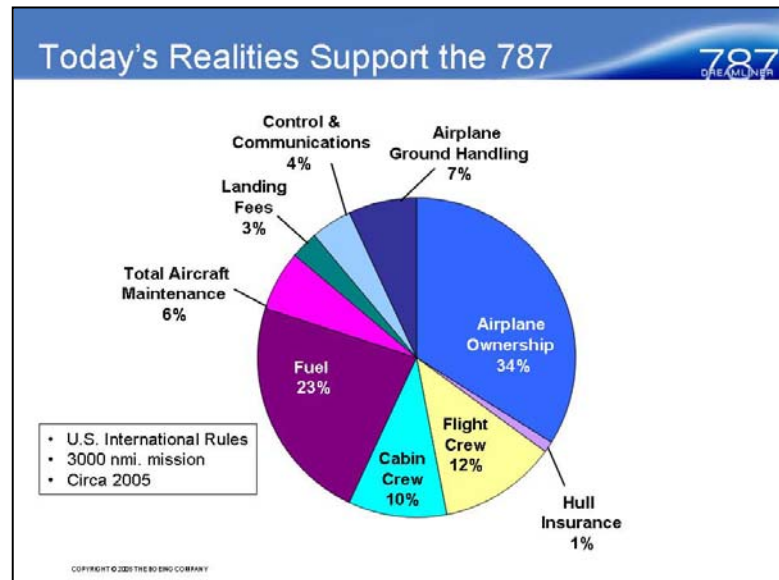


*Total airplane operating costs, based on 2001 fuel prices*

When Boeing looked at the elements of cost associated with operating an airplane in 2001, fuel was 12 percent of the operating cost. At that time, Boeing engineers and designers were considering the best application of technological advances to make a new and better airplane. We talked to our customers about two options:

1) Speed: (the Sonic Cruiser, which flew 15-20 percent faster than exiting models), or 2) fuel efficiency (the new 787 Dreamliner which offered a 20 percent improvement in fuel usage). The response of our customers was consistent and, by late 2003, it became strikingly clear what our customers wanted: a more fuel efficient airplane. This process of listening to the customer and understanding the real needs in the industry is the reason Boeing has been so successful for so long. This is how we always make our product decisions and it has allowed us to remain the industry leader.

Even when fuel was 12 percent of airline operating costs, it was a significant enough concern to point the entire industry toward improving fuel efficiency. A look at how those costs have changed with the rising price of fuel makes it even more obvious why efficiency is the right answer for our industry.



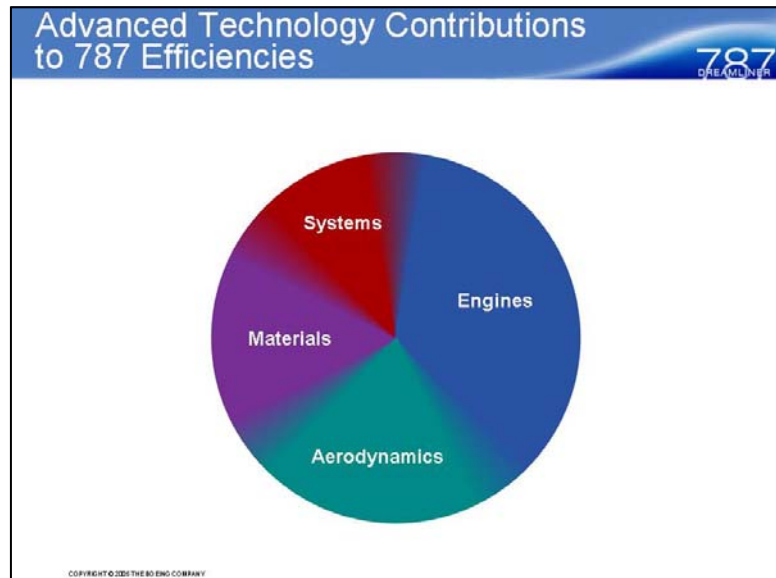
*Operating costs in 2005, with increased cost of aviation fuel*

By 2005, fuel prices had doubled, making the all-new 787 Dreamliner an even more compelling product.

### **787- The Most Fuel Efficient Commercial Jet Airliner**

In December 2003, the Boeing Company announced it would begin offering the 787 Dreamliner to the airline industry. The reaction to the plane was immediate and extremely positive. In the 787, customers saw a new design and efficiencies that were once unthinkable, including:

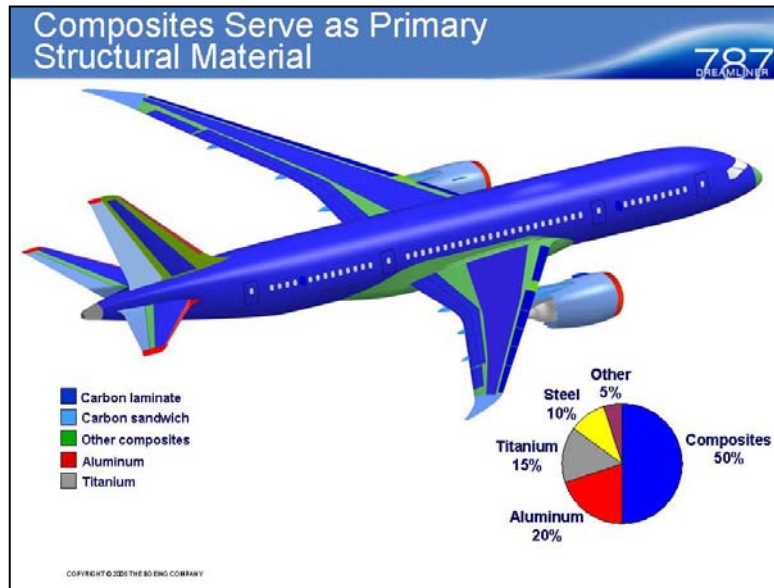
- The first airplane made primarily of light-weight sturdy carbon composites
- A mid-sized airplane that could travel the distances that only large airplanes had previously achieved
- More cargo capability than similarly sized airplanes
- Maintenance schedules that could offer them significantly more flying days
- Next generation “no-bleed” engines with higher bypass ratios
- An enlarged cabin interior with windows 50 percent larger than competing aircraft
- An airplane that offers a 20 percent improvement in fuel use as part of an overall improvement of 10 percent lower operating costs



*Technology advances combine to provide a 20 percent improvement in fuel use*

How was Boeing able to bring these efficiencies to the 787? Stated simply, fuel use improvements come from technological innovations in **materials** (what the airplanes are made of), **systems** (the hardware and software that make the airplane work), **aerodynamics** (our ability to optimize the airplane shape and weight for efficiency) and **engines**. At different times in history, gains have been made in different proportions for each of these areas. On the 787, significant gains in each of these disciplines have created a revolutionary airplane.

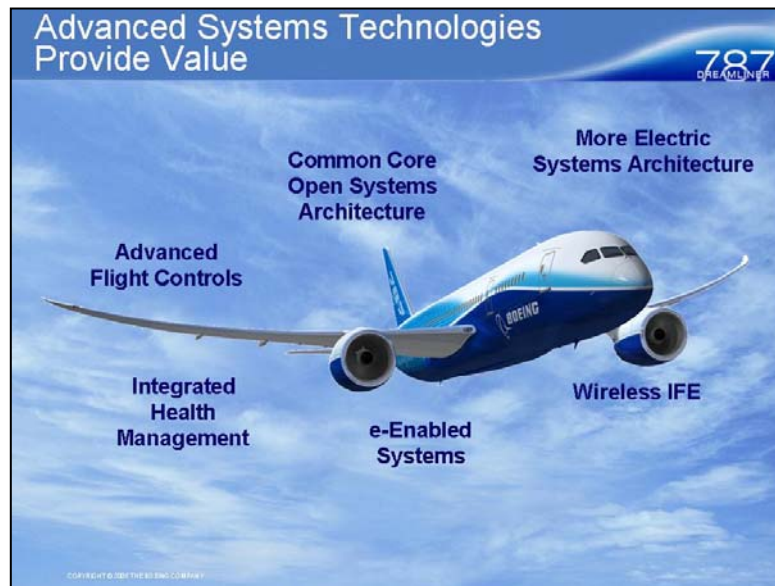
Independent of one another, these four technologies (materials, systems, aerodynamics, engines) provide about a 17 percent improvement in fuel use. By integrating them together and creating an all-new airplane designed with these technologies, Boeing is able to gain an overall improvement of 20 percent. This is one case where the sum is truly greater than just a combination of the parts. Each of these technologies will be addressed in the following pages.



*Composites provide significant weight savings*

**Materials** – The Boeing 787 will be the first commercial jetliner made primarily of composite materials. This development is the foundation of the ground-breaking airplane. Lightweight materials directly reduce the amount of fuel needed. This same composite material has been in service on Boeing 777 jetliners for more than 10 years. Boeing understands this material and its advantages very well. Just 10 years ago, the ability to manufacture large pieces of airplane structure from this material simply did not exist. The processes were labor intensive creating an economic challenge in using this superior material. Boeing and the 787 team of international partners have invented new methodologies to close this economic gap and enable the use of this lighter, more efficient material for major pieces of airframe structure.

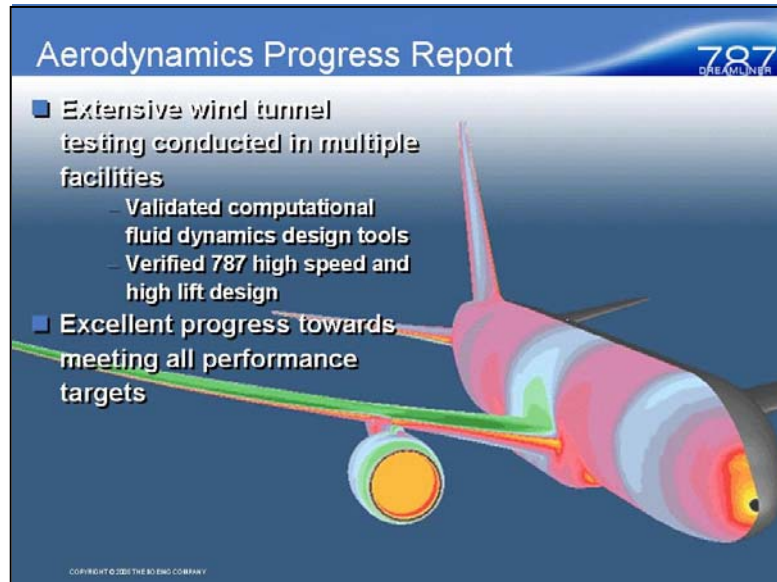
The advantages offered by composite materials go well beyond their light weight, high strength performance. This material is extremely resistant to fatigue and corrosion – the natural enemies of aluminum that drive so much maintenance and cost on today's airplanes. Boeing is guaranteeing the airlines 30 percent reduction in maintenance costs with the 787, largely because of the extensive use of these superior composite materials. Also, because it is so strong, Boeing can create a better flying experience for passengers by offering bigger windows, a lower altitude in the cabin (which increases the amount of oxygen) and increasing the moisture in the air for more comfort.



*Advanced airplane systems save weight and fuel*

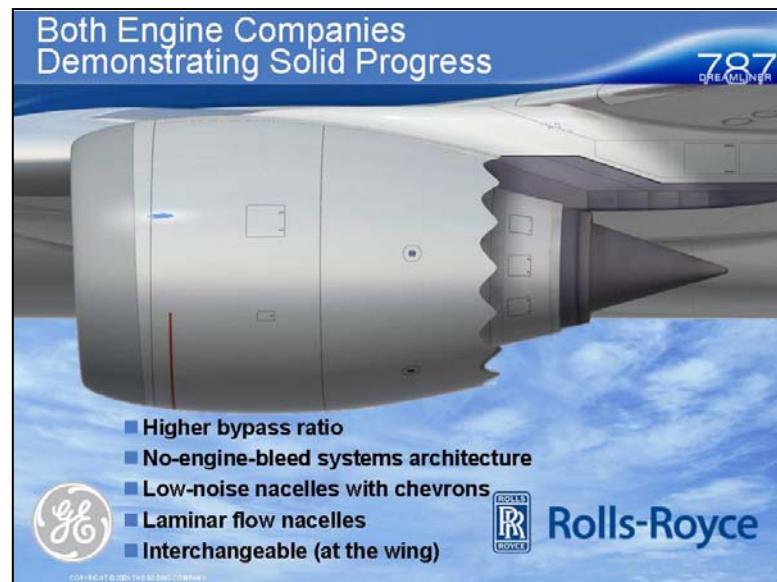
**Systems** – Advances in the reliability and sizing of power electronics have allowed Boeing to create an all-new more-electric systems architecture for the 787 Dreamliner. There are several advantages to this new systems approach. First, the electric systems eliminate the need to extract “bleed” air from the engines. Bleed-air systems rob engines of efficiency, add weight to the airplane and increase the maintenance burden. In the 787, they are removed. Instead of investing in trying to make this old pneumatic technology more efficient, Boeing is taking advantage of advances made in electronics to completely replace it, increasing the reliability of the airplane, reducing maintenance and lowering weight.

Improvements in flight deck systems – like standard dual head up displays and new larger format displays – will provide pilots with greater situational awareness further improving the safety of each flight. This enables the 787 to be well prepared for next-generation air traffic control systems.



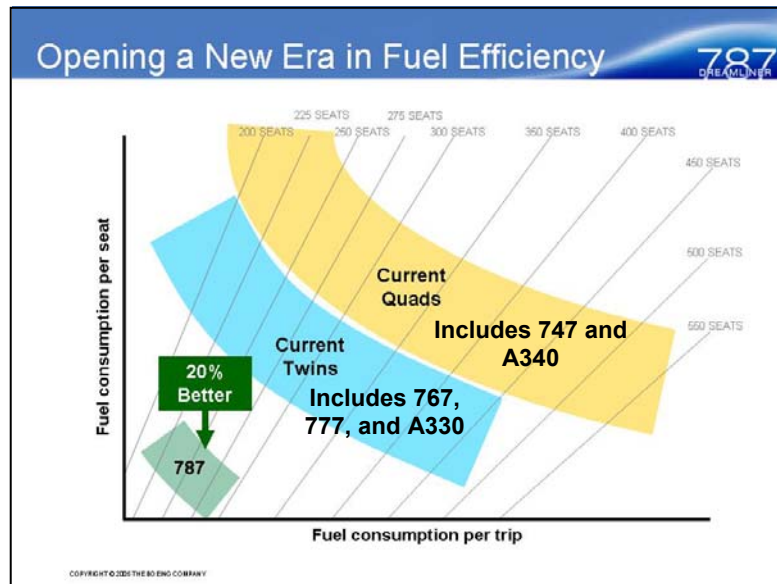
*Use of modern computational fluid dynamics and wind tunnels reduce drag fuel*

**Aerodynamics** – Through the use of advanced computational codes run on Cray supercomputers, the Boeing team has been able to consider numerous refinements of the aerodynamic shaping of the 787. Aerodynamic shaping relies on very small changes to the external structure of the airplane to create a better flow of air over those surfaces in flight. By optimizing the design with the use of these tools, the team was able to create about 3 percent of the total fuel savings for the 787.



*Modern high bypass ratio engines are fuel efficient*

**Engines** – Both General Electric and Rolls-Royce are developing new engines for the 787 Dreamliner. These engines use new materials and new technologies to create about 8 percent of the overall fuel savings experience with the 787.



*The 787 Dreamliner provides a significant improvement in fuel efficiency*

When compared to comparably sized airplanes from either Boeing or Airbus; the 787 is opening up a new level of performance in the fuel efficiency arena. This 20 percent savings in fuel results in a 10 percent or more reduction in airline operating costs. For an industry operating on negative to slim margins, a 10 percent improvement in operating costs is very significant.

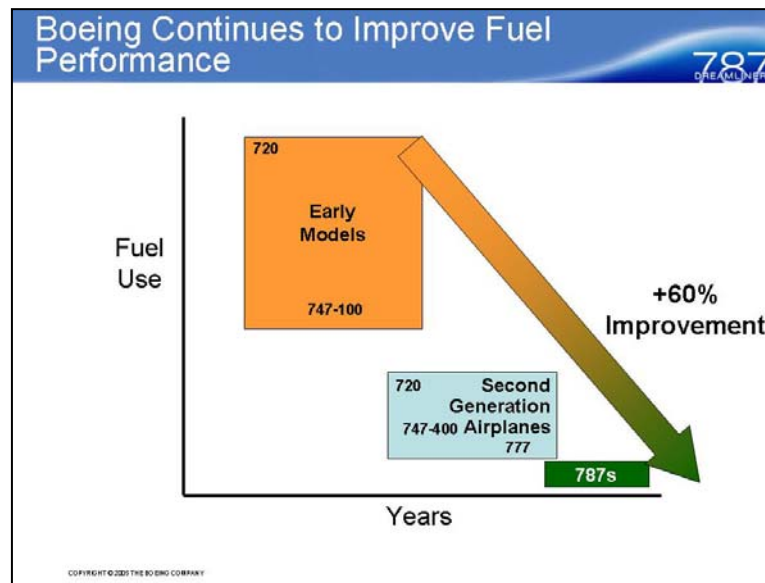
The Boeing order book is proof of how this technology is being received by the aviation marketplace. With 27 customers from around the world and 291 firm orders and another 88 committed orders, it is clear the 787 is providing a new level of performance that will provide value to the airlines and save substantial fuel resources.

The diversity of the customer base – with operators from five continents, large carriers, small carriers, established carriers, start-up carriers, those with regularly scheduled service and those with charter business or exclusive tour arrangements, as well as leasing companies – also demonstrates the flexibility of the aircraft in helping to serve a variety of business case needs.

Compared to a 767 or A330-200 a 787 will save about 5,000 gallons of fuel per flight on a 6,000 nautical mile mission. In a one year period, this results in a savings of two million gallons per airplane. Even if we estimate that Boeing only receives half of the orders for the anticipated size of the market for this airplane, that is a savings of 3.6 billion gallons of fuel saved over the next 20 years. If Boeing continues to experience the strong market demand it has already seen, that number will increase.

In terms of fuel consumption, the Boeing 787 Dreamliner is the right airplane at the right time.

## Improvements Introduced in Other Boeing Aircraft



*Significant fuel savings with each new generation of jet transport*

With each new airplane Boeing has developed, technologies have evolved to improve fuel use. From the introduction of the 707 into revenue service on Oct. 26, 1958, to the all-new Boeing 787 Dreamliner being designed today, Boeing commercial jetliners have achieved a more than 60 percent improvement in fuel use.

**737** – There have been two major rounds of improvements offered on the 737 airplane. Today's 737s have new a wingtip design, know as winglets, that help improve fuel efficiency. In addition, advances in engines, materials and systems have led to a series of improvements in fuel use. In the first major step, fuel use was improved by about 20 percent. The most recent models use 15 percent less than the improved 737s.

**777** – Even the newest of our commercial jetliners have seen improvements introduced to help reduce fuel use. New raked wingtips are helping to reduce fuel use as are advances in materials and systems. In addition, today's 777 engines are even more fuel efficient than those delivered just a few years ago.

**747-8** – 787 technologies are now being leveraged to help improve the fuel efficiency, overall performance and market appeal of other Boeing Commercial jetliners. The Boeing 747-8 Intercontinental and 747-8 Freighter are the new high-capacity 747s that offer airlines the lowest operating costs and best economics of any large passenger or freighter airplane. Boeing launched the airplane on November 14.

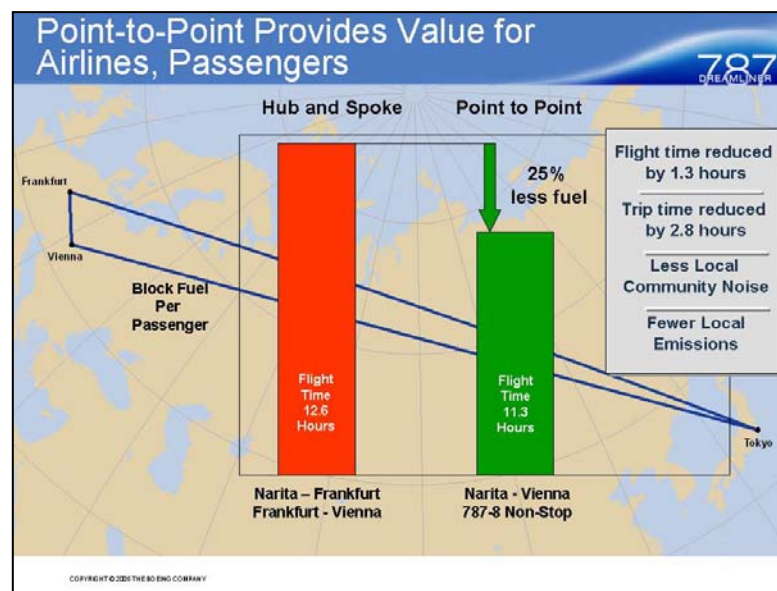
Boeing had been studying the market feasibility of a new 747 for some time, working with operators to establish their requirements for an incrementally larger 747 to continue the profitability of current 747 fleets. By working together with

customers and applying the innovative new technologies of the 787 Dreamliner (e.g. 787 engines), Boeing is able to create the 747-8 family. In fact, the designation 747-8 was chosen to show the technology connection between the 787 and the new 747.

The 747-8 Intercontinental is more than 13 percent lighter per seat than the A380, and consumes 14 percent less fuel per passenger. That translates into a trip-cost reduction of 22 percent and a seat-mile cost reduction of more than 6 percent compared to the A380

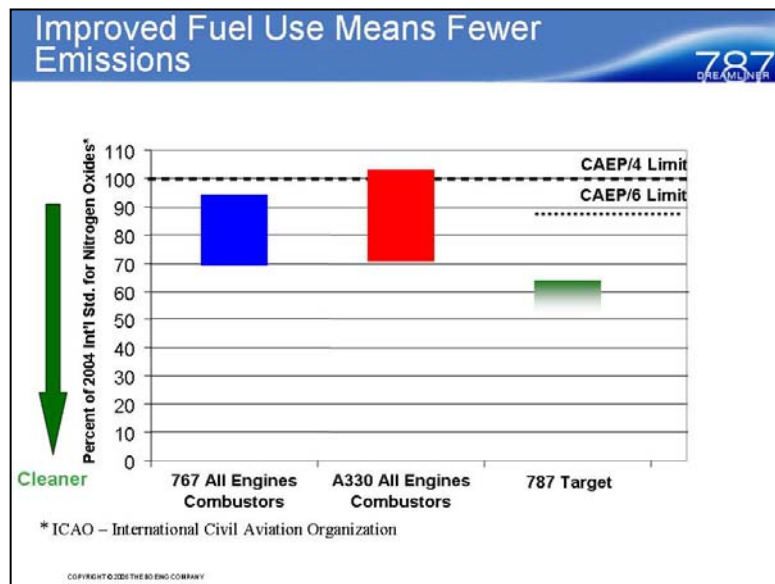
**Future Airplanes** – The technologies being introduced on the 787 will continue to mature and improve in the years ahead, offering fertile ground for the next all-new Boeing airplanes for decades to come. Composite materials will continue to evolve to be lighter and more durable. Power electronics will become more powerful and lighter weight, aerodynamics codes will become more sophisticated and engines will become more efficient. This is the constant rhythm of improvement that Boeing helps to drive to ensure that each new airplane offers better performance and better value.

## **OTHER 787 ADVANTAGES, ENVIRONMENTAL BENEFITS**



*By using less fuel and providing direct routes, the 787 offers improvements*

**Point-to-Point** – By connecting mid-sized cities directly, the 787 will relieve traffic from overcrowded hubs and allow passengers to travel directly from their point of origin to their destinations. The 787 will have ETOPS capabilities – permission from regulators to use more direct routes over water. It will travel less distance in connecting long-haul city pairs. These two factors will help save fuel and a resource that passengers also consider precious – their time.




*The 787 meets current and anticipated emissions regulations*

**Emissions** – A 20 percent reduction in fuel use equates to a 20 percent reduction in carbon dioxide emission. Compared to today’s airplanes, the 787 will produce fewer nitrogen oxides emissions, meeting and exceeding current environmental standards.



**Noise** – Community noise is another environmental performance issue that airplanes have continuously improved throughout the jet age. The 787 has a 66 percent smaller footprint at the 85 dBA level (roughly equivalent to the sound heard when standing near a busy street and large truck passes by). In fact, for every airport studied so far, this 85dBA noise stays within airport boundaries for the 787.

Superior Cabin Environment  
Designed for Passenger Well Being
787  
DREAMLINER



- **Lower Cabin Altitude (8,000 feet)**
  - Oxygen increased by 8%
- **Smoother Ride**
  - Light to moderate turbulence mitigated
- **Quieter Cabin**
  - Meets stringent new requirements
- **Higher Humidity**
  - Reduces discomfort
- **Improved Lighting**
  - Increases well being
- **Bigger Windows**
  - Connects passengers to the flying experience

- **Air Purification**
  - Advanced filtration technologies result in cleaner air
  - Reduces dryness symptoms
- **Air Management**
  - Personal air outlets for each passenger
  - Improved cabin air flow
- **More Personal Space**
  - Personal air outlets for each passenger
  - Larger stowage bins
  - Increased headroom
  - Wider seats and aisles

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*The 787 offers passengers a better flying experience*

**Cabin Environment** – Another key environmental consideration in the design of commercial aircraft is the environment for passengers traveling inside the cabin. We have introduced a number of new technologies – ranging from cleaner air to higher humidity and larger windows to help passengers better enjoy their flying experience onboard the 787 Dreamliner.

### **The Air Traffic Control System – Improvement Is Needed**

Given everything I have already said about the fuel efficiency of our newer aircraft, we must recognize that aircraft technology is only part of the equation. The efficiency of the airspace system directly impacts the fuel usage of an aircraft in operation. The benefits of fuel efficient aircraft technology cannot be fully achieved if aircraft cannot perform at optimal levels and are required to fly inefficient routes or approaches, fly in holding patterns, fly at less than optimum speeds, or sit idling on the ground.

The progress of improvements in air traffic management has not kept pace with the dramatic advancement in technology onboard the aircraft. As a result, our aircraft are not being utilized to their fullest potential. As aircraft and engine manufacturers continue to bring fuel efficiency improvements to the market, the FAA must also improve the efficiency of the airspace system to ensure that the full benefits of these improvements can be realized.

Let me give you a few examples of airspace improvements that could dramatically improve fuel efficiency of aircraft flying in the system:

- **Required Navigation Performance (RNP)** – developing approaches to airports based on RNP allows aircraft to take advantage of onboard precision

instrumentation to fly more optimal routes. Instead of flying a route based on where ground based equipment is located, an aircraft can fly a more direct route into the airport.

- **Tailored Arrivals** – Tailored arrivals allow an air traffic controller to use data-link to send a 4 dimensional (route plus time) flight profile directly to the flight deck of an approaching aircraft when it is ready to begin its descent, about 140 miles away from its final destination. Once reviewed by the flight crew, the optimized trajectory is entered into the flight management system (FMS) with a simple keystroke. The FMS then flies the given trajectory to touchdown with a high degree of accuracy. Air traffic management computers calculate and submit the most efficient approach path, given local traffic and weather conditions, hazardous terrain, noise restrictions and the aircraft's own performance capabilities. Using the aircraft's area navigation (R-NAV) capabilities, which frees the crew from having to follow fixed navigation points on the ground, aircraft can follow efficient, curved, continuous descent approaches, rather than a traditional step-down approach. The aircraft stays higher longer and descends quicker at a very low throttle setting. In 2004 Boeing and the Air Traffic Alliance (Airbus, EADS, and Thales) jointly tested the Tailored Arrivals concept with Qantas in Sydney and Melbourne, Australia. Results of that test showed savings of between 400-800 pounds of fuel per flight, which adds up to more than \$100,000 per year per aircraft. Tailored Arrivals can be implemented using the existing equipment found on current generation commercial aircraft flying in the air traffic control system today.
- **Trajectory Based Operations** – fuel efficiencies enroute will also be realized with a move to trajectory based operations and more precise airspace usage. Reducing ground holds, in trail spacing and other flow restrictions, improving weather avoidance efficiencies, oceanic spacing reductions and flexible climb clearances, as well as allowing optimum speed use and passing -- all of these are fuel saving benefits (and emissions as well).

Mr. Chairman, Boeing is doing its part to make better, more fuel efficient aircraft. However, these gains could be totally eclipsed if the current air traffic control system does not realize similar efficiencies in the future. This is one area where this sub-committee and the Congress can help in creating a more fuel efficient air traffic control system. As you look toward reauthorizing the FAA in 2007, please keep this in mind.

## CONCLUSION



*The Boeing 787 Dreamliner will be the most fuel efficient commercial airliner in the world*

Improved fuel efficiency and overall environmental performance is the right thing to do both in terms of conserving precious resources and in providing a business tool for airlines that will help them to stabilize their business models. Boeing has developed the 787 because it is the airplane our customers want and need. We have taken similar strides with the 737, 747, 767 and 777. This is how we have developed airplanes for decades and is the reason we are more successful than any other manufacturer. It is one reason we are confident that the 787 will be a market success. These technologies will continue to mature allowing Boeing to develop and deliver new airplanes with better performance in the years to come.

With this airplane Boeing is once again reshaping the commercial airline industry – from the way we do business to the business opportunities provided to our customers. While we often measure the improvements offered by our airplanes on a customer-by-customer basis, it is equally true that the advantages offered by the 787 will result in savings for the entire commercial transport system. Combined with other industry efforts, like advances in air traffic control technologies, Boeing's new more fuel efficient jetliners will make a difference in reducing the resources used to transport people over long distances.

Again, Mr. Chairman, I appreciate this opportunity to testify before the subcommittee.